

OWNER

Measurement System Design Basis and Philosophy

Report



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CONTENTS

1.	INTRODUCTION	1
1.1.	PURPOSE.....	1
1.2.	SCOPE	1
1.3.	EXCLUSIONS	1
2.	CUSTODY ARRANGEMENT	2
3.	METER SELECTION	3
3.1.	DUTY.....	3
3.2.	ALTERNATIVES.....	3
4.	RUN CONFIGURATION.....	4
4.1.	ARRANGEMENT	4
4.2.	VALVE POSITIONS.....	6
4.3.	DUTY ASSIGNMENT	6
4.4.	AUTOMATIC RUN SWITCHING.....	6
5.	VERIFICATION	8
5.1.	SERIES COMPARISON.....	8
5.2.	SPEED OF SOUND CHECK.....	8
5.3.	RECALIBRATION	8
6.	GAS QUALITY AND COMPOSITION	9
6.1.	ANALYZERS	9
6.2.	COMPOSITION FALLBACK	9
7.	FLOW COMPUTER, DATA AND RECORDS.....	11
7.1.	FLOW COMPUTER.....	11
7.2.	WITNESS AND DATA INTERFACE.....	11
7.3.	RECORDS AND AUDITS	11
8.	SUMMARY AND CONCLUSIONS	12

FIGURES AND TABLES

Figure 4-1. Meter Skid General Arrangement	5
Table 3-1: Meter Technology Comparison.....	3
Table 4-1: Meter Valve Positions by Mode.....	6
Table 4-2: Run Switching Logic	7
Table 6-1: Gas Quality Measurement	9
Table 6-2: Composition Source Priority.....	9



1. INTRODUCTION

1.1. PURPOSE

This report sets out how gas will be measured for custody transfer at the (), where the Owner delivers up to 120 MMSCFD of treated gas into a operated by , the receiving pipeline operator. It explains the choice of meter technology, the arrangement of the meter runs and how they are switched, how the meters are verified in service, how gas quality is measured and what happens when the chromatograph is unavailable, what the receiving pipeline operator witnesses and receives, and how measurement records are kept. Each choice is stated with its reason and with the alternatives that were rejected.

1.2. SCOPE

The report covers the meter inlet header 12"-G-1010 through the meter outlet header 12"-G-1020, the sample probe SP-141 and analyzer shelter B-101, the flow computer FQI-110 in control building B-102, and the measurement data path to the Owner's SCADA and to the receiving pipeline operator's RTU. The supporting calculations are MEA-CAL-001 to CAL-004; the equipment is specified in MEA-SPC-001 and datasheets MEA-DS-001 to DS-010; operation is governed by procedures MEA-PRC-001 to PRC-004.

1.3. EXCLUSIONS

The fuel gas meter FT-163 is an Owner allocation meter and is covered only as an input to the station balance. The receiving pipeline operator's own measurement, RTU and remote shutoff at the tap are outside this report, as are the overpressure protection system and the flow control valves, which are covered in Volume 7.

2. CUSTODY ARRANGEMENT

Title to the gas passes at the outlet flange of the custody meter runs. The Owner will build, own, operate and maintain the station and its measurement; the receiving pipeline operator will have the right to witness every calibration, verification and meter change and will receive measurement data in real time. These terms are taken from the Basis of Design and remain subject to the Interconnect and Operating Agreement (HOLD H-01).

The custody quantities are volume at 14.73 psia and 60 °F, and energy on a dry gross heating value basis per GPA 2172. Composition, heating value, relative density, water content, hydrogen sulfide, oxygen and carbon dioxide are measured continuously. Fuel gas is taken upstream of the meters, so the custody meters see only delivered gas and no allocation between delivered and consumed gas is needed.

The Basis of Design sets uncertainty targets of $\pm 0.5\%$ on volume and $\pm 0.6\%$ on energy at 95 % confidence. The Owner has decided that these targets apply from 20 to 120 MMSCFD. Below 20 MMSCFD the meter operates under its transition flow rate and the expected figures are $\pm 0.53\%$ and $\pm 0.62\%$. MEA-CAL-002 gives 0.40 % on volume and 0.51 % on energy at normal and maximum flow, so the design meets the targets with margin.

Both parties will convert volume with the same equation of state. AGA 8 Detail and GERG-2008 differ by up to 0.10 % for the design gas (MEA-CAL-003), a bias that would show up in every monthly balance if the parties used different equations. The flow computer will run AGA 8 Detail, with GERG-2008 selectable, and the choice will be written into the Interconnect Agreement.

3. METER SELECTION

3.1. DUTY

The meter must cover 10 to 120 MMSCFD, a 12:1 turndown, at 887 to 1,137 psig and 44 to 119 °F, in dry sweet pipeline-quality gas, with zero-emission actuation throughout the station.

3.2. ALTERNATIVES

TORUS compared multipath ultrasonic, orifice and Coriolis meters. Table 3-1 summarizes the comparison.

Table 3-1: Meter Technology Comparison

Criterion	Multipath ultrasonic (AGA 9)	Orifice (AGA 3)	Coriolis (AGA 11)
Range in one run	2.8 to 38.4 ft/s in NPS 10, against a typical 1.5 to 100 ft/s	144.7 in H ₂ O at full flow falls to 0.9 in H ₂ O at turndown (NPS 12, beta 0.60)	4,074 lb/min at full flow needs the largest gas sizes or two meters
Permanent loss at full flow	2.36 psi for the whole run	About 3.2 psi plus conditioner	Typically 5 to 15 psi
Uncertainty after calibration	0.40 % volume	0.6 to 1.0 % without flow calibration	About 0.35 to 0.5 % of mass
Diagnostics	Per-path speed of sound, gain, profile; check against AGA 10	Plate inspection only	Drive gain, tube health
In-service verification	Series comparison of two identical meters	Plate inspection	Series comparison possible

The orifice meter was rejected because a single run cannot cover the turndown: flow varies with the square root of differential, so 12:1 in flow is 144:1 in differential, and at 10 MMSCFD the differential is below 1 in of water. It would need multiple plates or a parallel low-flow run, adds about 3 psi of permanent loss, and has a higher uncertainty. The Coriolis meter is feasible but at 120 MMSCFD it is large and heavy, has a higher pressure loss at this gas density, and offers no uncertainty advantage once energy, which requires the chromatograph anyway, is the custody quantity.

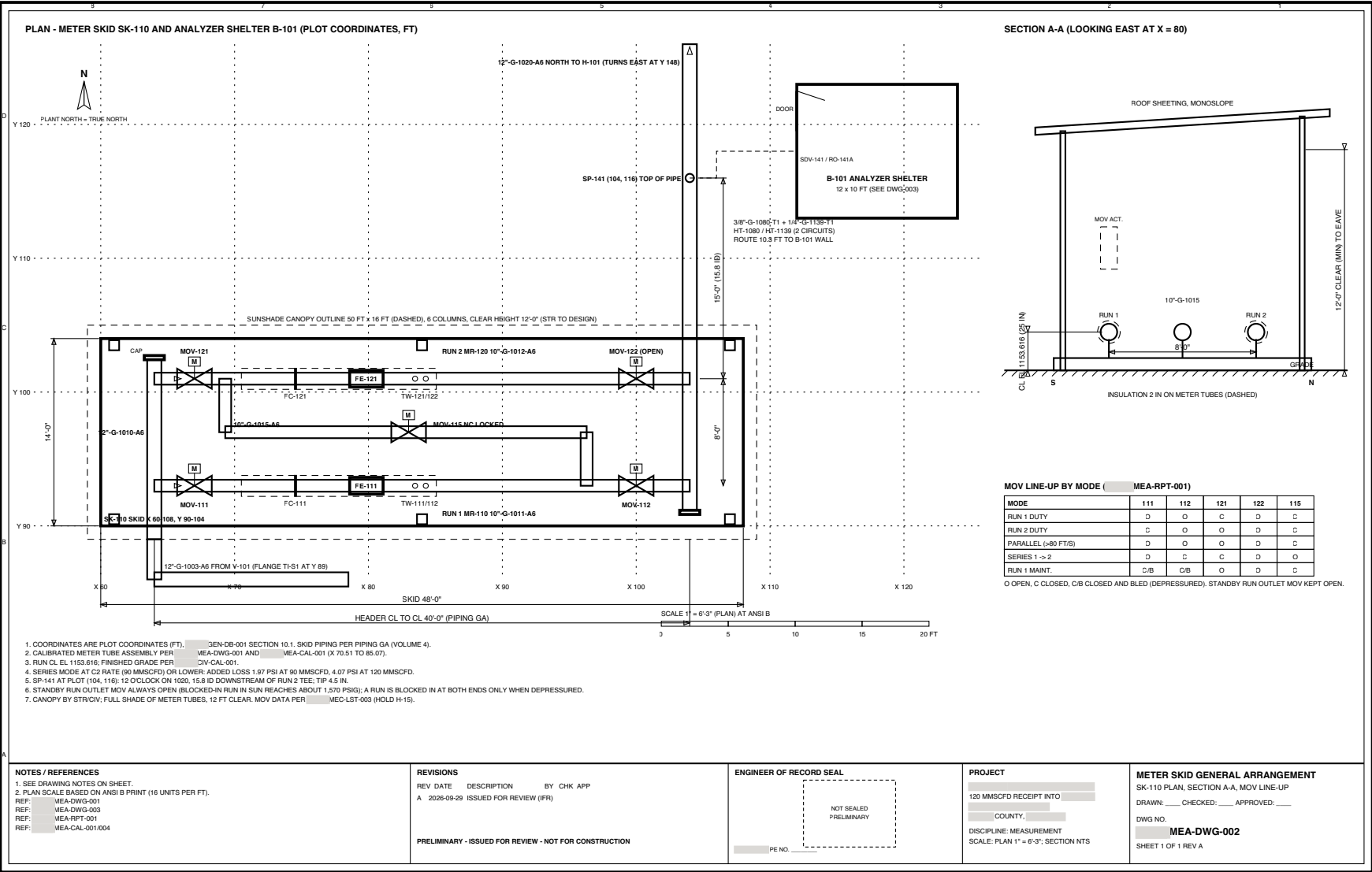
The multipath ultrasonic meter covers the whole range in one NPS 10 run with negligible body loss, carries diagnostics that detect most failures between calibrations, and allows two identical meters to verify each other in series. It was selected, with two runs of 100 % capacity each, each flow calibrated with its own meter tube and conditioner.

4. RUN CONFIGURATION

4.1. ARRANGEMENT

Figure 4-1 shows the meter skid. Two identical runs, MR-110 and MR-120, run between the inlet and outlet headers; each has an inlet and outlet motor-operated valve with double block and bleed, a perforated-plate conditioner 5 diameters upstream of the meter, and 10 diameters of straight pipe upstream in total. A crossover, 10"-G-1015 with MOV-115, joins the downstream end of run 1 to the upstream end of run 2 so that the two meters can be placed in series.

Figure 4-1. Meter Skid General Arrangement



The conditioner and 10D arrangement was chosen because the only upstream disturbance is a header tee and a full-bore valve, which a tested plate handles in that length, and because the tube, conditioner and meter are calibrated together, which removes their interaction from the uncertainty. The meter tubes are insulated and the skid is shaded, because in sun a bare tube at low flow runs several degrees warmer at the top, where the thermowells are, and 1 °F is 0.34 % of volume (MEA-CAL-001).

4.2. VALVE POSITIONS

Table 4-1 gives the valve positions in each operating mode. The standby run is kept with its outlet valve open and only its inlet valve closed. A gas-filled run closed at both ends and heated by the sun would reach about 1,570 psig, above the 1,440 psig design pressure (PRO-CAL-007). Keeping the outlet open holds the standby run at outlet header pressure without a relief valve, and lets it be brought on line by opening one valve. The standby meter stays powered; any flow it registers indicates inlet valve seat leakage, and that flow is still measured.

Table 4-1: Meter Valve Positions by Mode

Mode	MOV-111	MOV-112	MOV-121	MOV-122	MOV-115	Meters in service
Run 1 duty	Open	Open	Closed	Open	Closed	FE-111
Run 2 duty	Closed	Open	Open	Open	Closed	FE-121
Both runs in parallel	Open	Open	Open	Open	Closed	FE-111 and FE-121
Series verification	Open	Closed	Closed	Open	Open	FE-111, then FE-121
Run 1 maintenance	Closed, bled	Closed, bled	Open	Open	Closed	FE-121

Note 1: A run is closed at both ends only for maintenance, after it has been depressured to the vent header.

MOV-115 is locked closed at its actuator except during verification, because a seat leak across it would let gas bypass the duty meter. Its body cavity bleed is checked before every verification.

4.3. DUTY ASSIGNMENT

The operator selects the duty run from SCADA. Duty is rotated at each quarterly verification so that both meters accumulate comparable service.

4.4. AUTOMATIC RUN SWITCHING

One run carries every basis case at no more than 38 % of the meter's typical maximum. Automatic opening of the second run is therefore a capacity reserve and a failover function rather than part of normal operation. Table 4-2 sets the logic, which the flow computer and RTU will carry.

Table 4-2: Run Switching Logic

Function	Trigger	Action
Open second run	Duty run above 80 ft/s (80 % of maximum, about 250 MMSCFD) for 60 s	Open the standby inlet valve; the outlet is already open
Return to one run	Both runs below 30 ft/s each for 10 min	Close one inlet valve only; its outlet stays open
Diagnostic failover	Duty meter failure, too few healthy paths, or speed-of-sound alarm confirmed by path diagnostics	Open the standby inlet valve, confirm flow, then close the failed run's inlet valve
Transfer interlock	MOV-115 not proven closed	Inhibit any automatic change and alarm
Blocked-in protection	Both valves of one run closed without the maintenance permissive	Alarm and inhibit the second closure
High velocity	Any run above 90 ft/s	Alarm; station flow control limits flow

The switching points are 80 % and 30 ft/s per run, which is 60 % of maximum on a single-run basis. The 20 % gap prevents cycling between one and two runs. Two runs are never kept open at low flow, because splitting the flow halves the velocity and pushes both meters toward their less accurate low-flow band. Failover is make-before-break so that no gas passes unmeasured.

5. VERIFICATION

5.1. SERIES COMPARISON

With the series line-up of Table 4-1, all gas passes FE-111 and then FE-121. The comparison will be made at least quarterly, and after any diagnostic alert, meter or electronics change, conditioner inspection, or request by the receiving pipeline operator. It will be run at 90 MMSCFD or lower, because series flow adds 1.97 psi at 90 MMSCFD and 4.07 psi at 120 MMSCFD, which at low inlet pressure would reduce the station's delivery capacity.

The meters must agree within 0.3 % over at least three consecutive hourly periods after 30 minutes of stabilization. Between 0.2 and 0.3 % the result is recorded and the diagnostic trends reviewed; above 0.3 % both meters are investigated, and the meter that disagrees with its own diagnostics is removed for recalibration. MEA-PRC-001 sets out the procedure.

A series comparison detects divergence between the two meters but not a shift common to both. That is covered by the speed-of-sound check and by periodic flow recalibration.

5.2. SPEED OF SOUND CHECK

The flow computer will compare each meter's measured speed of sound with the AGA 10 value calculated from the live pressure, temperature and composition. The expanded uncertainty of that difference is 0.22 % (MEA-CAL-003), so the check will alert at ± 0.25 % over an hour and alarm at ± 0.40 %. The check is also a check on the chromatograph and on the temperature measurement: a 1 mol % composition error or a 1 °F temperature error shows up clearly, which is why a deviation shared by both meters is investigated at the chromatograph and thermowell first.

5.3. RECALIBRATION

Flow recalibration will follow the interval in the Interconnect Agreement (HOLD H-01). TORUS recommends the first recalibration at three years, or earlier on diagnostic evidence, with as-found and as-left data so that any correction can be applied to the period since the last good verification.

6. GAS QUALITY AND COMPOSITION

6.1. ANALYZERS

Table 6-1 lists the gas quality measurements. The sample is taken at SP-141 on the meter outlet line, downstream of both runs, reduced to 25 psig at a heated probe regulator, and carried 20 ft in heat-traced tubing to B-101; the transport lag is 15 s (MEA-CAL-004). A shutoff valve SDV-141 with a restriction orifice at the shelter wall closes the sample line on station ESD.

Table 6-1: Gas Quality Measurement

Tag	Measurement	Range and alarm	Tariff limit (HOLD H-13)
AT-141	Chromatograph, C1 to C5, hexanes plus, N ₂ , CO ₂ ; cycle 5 min or less	Hourly average to FQI-110	970 to 1,150 Btu/scf; CO ₂ 2.0 %; inerts 4.0 %
AT-142	Water vapor, tunable diode laser	0 to 20 lb/MMscf, alarm 7	7 lb/MMscf
AT-143	Hydrogen sulfide, lead-acetate tape	0 to 16 ppmv, alarm 4	0.25 grain/100 scf
AT-144	Oxygen, electrochemical	0 to 100 ppmv, alarm 10	10 ppmv
SMP-146	Flow-proportional composite, 500 cm ³ cylinder, monthly		Verification and extended analysis

Out-of-specification gas alarms to the Owner and to the receiving pipeline operator. If it persists for 15 minutes (adjustable), the control system ramps the flow controller to zero and then closes the outlet shutdown valve.

6.2. COMPOSITION FALLBACK

The chromatograph is a single unit, so the flow computer needs a defined source of composition when it is unavailable. Table 6-2 sets the order.

Table 6-2: Composition Source Priority

Priority	Source	Used when
1	Live hourly average of valid analyses	Chromatograph healthy and at least 75 % of the hour's analyses valid
2	Last good hourly composition	Chromatograph alarm, invalid hour, SDV-141 closed, or the 2.5 min purge after it reopens; up to 24 h
3	Fixed composition from the latest monthly composite	After 24 h, or when the last good hour is suspect
4	Retroactive correction	After repair, per the Interconnect Agreement

Every change of source is recorded as an event and flagged in the hourly and daily records and in the data sent to the receiving pipeline operator. The 24 h and composite periods are defaults to be confirmed in the Interconnect Agreement (HOLD H-01).



7. FLOW COMPUTER, DATA AND RECORDS

7.1. FLOW COMPUTER

FQI-110 is a dual-run flow computer in B-102, on the station UPS, meeting API MPMS Chapter 21.1. It reads each meter by serial link with a frequency output as a totalizer check, takes absolute pressure and 4-wire temperature per run, receives composition from the chromatograph, and calculates volume, energy and the AGA 10 check. It paces the composite sampler, carries the run switching logic, and keeps the audit trail. Datasheet MEA-DS-008 specifies it.

7.2. WITNESS AND DATA INTERFACE

The receiving pipeline operator will be notified and invited to witness laboratory flow calibrations and factory tests (14 days' notice), site tests (7 days), series comparisons (7 days, or 24 h for a diagnostic-triggered check), chromatograph standard changes, transmitter calibrations and any meter removal. Configuration changes to FQI-110 will be notified in advance and recorded. Notice periods are typical and will be set by the Interconnect Agreement (HOLD H-01).

In real time the receiving pipeline operator will receive flow, daily volume and energy, meter pressure and temperature, heating value, relative density, water, H_2S , O_2 and CO_2 , the duty run and valve positions, shutdown valve status, alarms and the composition source flag, through a demarcation panel to its RTU. The point list, scaling and time synchronization will come from the receiving pipeline operator (HOLD H-14).

7.3. RECORDS AND AUDITS

Hourly and daily quantity records, configuration, event and alarm logs are kept per API MPMS Chapter 21.1, with at least three years recommended in the measurement system. Edits never overwrite originals, carry a reason and an approver, and are notified to the receiving pipeline operator. The station balance between the upstream allocation meter, the custody meters, fuel gas and recorded vents is reviewed daily for lost and unaccounted-for gas. MEA-PRC-004 sets out the procedure, and the Owner will audit the measurement annually.

8. SUMMARY AND CONCLUSIONS

TORUS recommends custody measurement with two NPS 10 multipath ultrasonic meters, each 100 %, each flow calibrated with its own tube and conditioner, verified against each other in series quarterly at 90 MMSCFD or lower and continuously against AGA 10 speed of sound. The standby run is kept pressurized through its open outlet valve, and the second run opens automatically only above 80 % of meter capacity or on failure of the duty meter. The chromatograph composition feeds the flow computer hourly, with a defined fallback. The expected uncertainty is 0.40 % on volume and 0.51 % on energy, within the targets from 20 to 120 MMSCFD.

The next steps are to agree the open terms of the Interconnect Agreement (HOLD H-01: witness, recalibration interval, equation of state, fallback periods, record retention), obtain the receiving pipeline operator's measurement requirements and point list (HOLD H-13, H-14), and replace typical vendor values with the selected vendors' data (HOLD H-15).

